

NATIONAL TRANSPORTATION SAFETY BOARD

Vehicle Recorder Division

Washington, D.C. 20594

April 7, 2005

Cockpit Voice Recorder Study - 12

Specialist's Report By Anna W. Cushman

A. EVENT

Location: Jefferson City, Missouri
Date: October 14, 2004, 2215 CDT*
Aircraft: CL-600-2B19, N8396A
Operator: Pinnacle Airlines (d.b.a Northwest Airlink), Flight 3701
NTSB Number: DCA05MA003

B. GROUP Group meeting not convened.

C. SUMMARY

On October 14, 2004, at about 2215 CDT, a Bombardier CL-600-2B19, operating as Pinnacle Airlines flight 3701 N8396A (d.b.a. Northwest Airlink), crashed in a residential area in Jefferson City, Missouri, about 2.5 miles south of the Jefferson City, Missouri airport. A solid-state cockpit voice recorder (CVR) was sent to the National Transportation Safety Board's Audio Laboratory for readout and a transcript was prepared for the 30-minute, 23-second digital recording (see the Group Chairman's Factual report and transcript). Additional evaluation of the CVR was required, as follows.

D. DETAILS OF INVESTIGATION

In examining the CVR recording, the following areas required further evaluation:

1. Microphone feedback squeal.
2. Loss of audio in the CVR channel 3 recording.
3. Captain's inability to transmit to ATC at the end of the recording.
4. Evaluation of radio transmissions using CVR, FDR, and ATC information.
5. Irregularity between radio transmission identity and source.
6. Synopsis of engine checklist usage, based on CVR events.

* All times are expressed in central daylight time (CDT) unless otherwise noted.

Data from three independent sources, which include the CVR, flight data recorder (FDR)[†] and air traffic control (ATC) audio re-recordings, are used to cross-check information, as necessary. Relevant information pertaining to the aircraft's audio system is provided, as follows[‡]:

Audio/communications system on N8396A

Per the aircraft maintenance manual for the CL600-2B19 (N8396A, serial number 7396), the audio/communication system enables crewmember communication (both radio communication and internal crewmember communication) by interfacing several systems, which include the communication transceivers, navigation receivers, aural warning system, passenger address and cabin interphone, CVR, FDR, and service interphone. The audio integrating system components include the audio control panels (see Figure 1), audio-electronic control unit (AECU), speakers, headphone/microphone jacks, and push-to-talk switches. The push-to-talk switches are located on the two control wheels and the three audio control panels. The AECU performs a vital role in the CVR study in that it processes all of the audio inputs and sends the information to the appropriate outputs, including the CVR and FDR (see Figure 2). Specific elements interfacing through the AECU are discussed in the appropriate sections that follow.

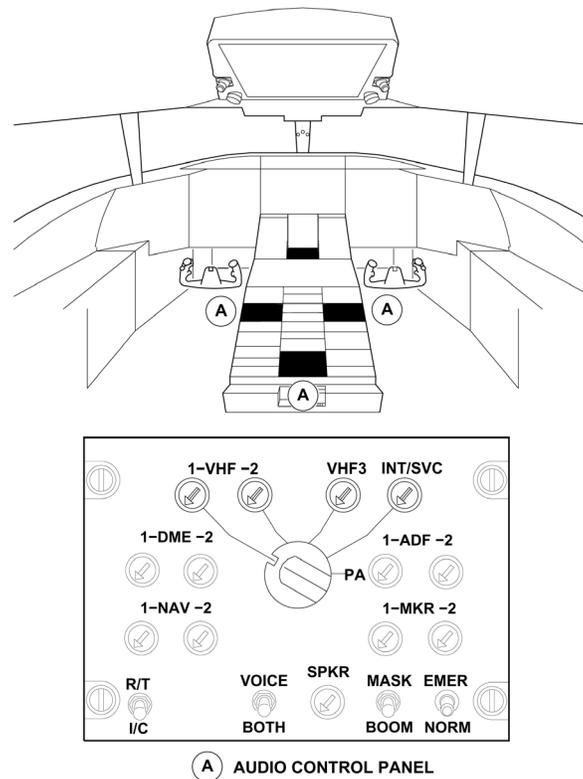


Figure 1: Audio control panel configuration and locations.

[†] Reference the Group Chairman's Flight Data Recorder Factual Report for more information.

[‡] Reference Chapter 23 sections 51 and 71 of the CRJ Aircraft Maintenance Manual for more information regarding the audio/communications and the CVR systems on the CL600-B219.

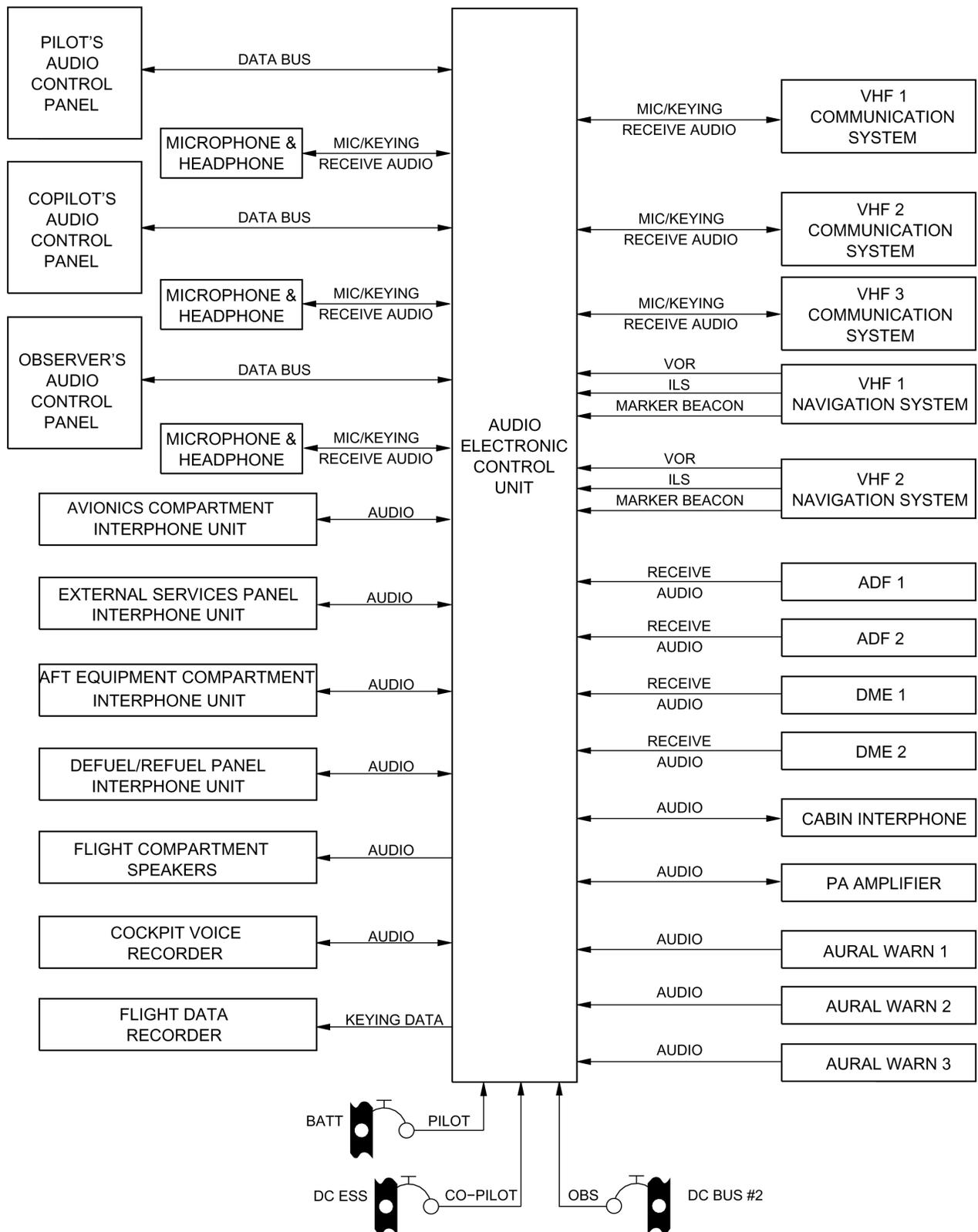


Figure 2: CRJ Aircraft Maintenance Manual, Audio Integrating System - Block Diagram

Cockpit Voice Recorder System

As stated in the CVR Group Chairman's Factual Report, the cockpit voice recorder installed on the accident aircraft was a solid state Fairchild A100S model CVR by L-3 Communications. The CVR is one component in the CVR system on the aircraft. The other components include the control unit, cockpit area microphone (CAM), impact switch and underwater locator beacon. From the aircraft maintenance manual, the CVR control unit contains a TEST switch for testing the functionality of the CVR, an ERASE switch to bulk erase the CVR recording, headset jack to listen to the audio as it is recorded, and a TEST indicator lamp. The CAM is located on the overhead panel and records the sounds and conversations that take place on the flight deck, including audio output from the cockpit speaker. The impact switch will open and remove power to the CVR if the aircraft goes into a rapid deceleration in excess on 2 g's. The components are integrated as shown in Figure 3.

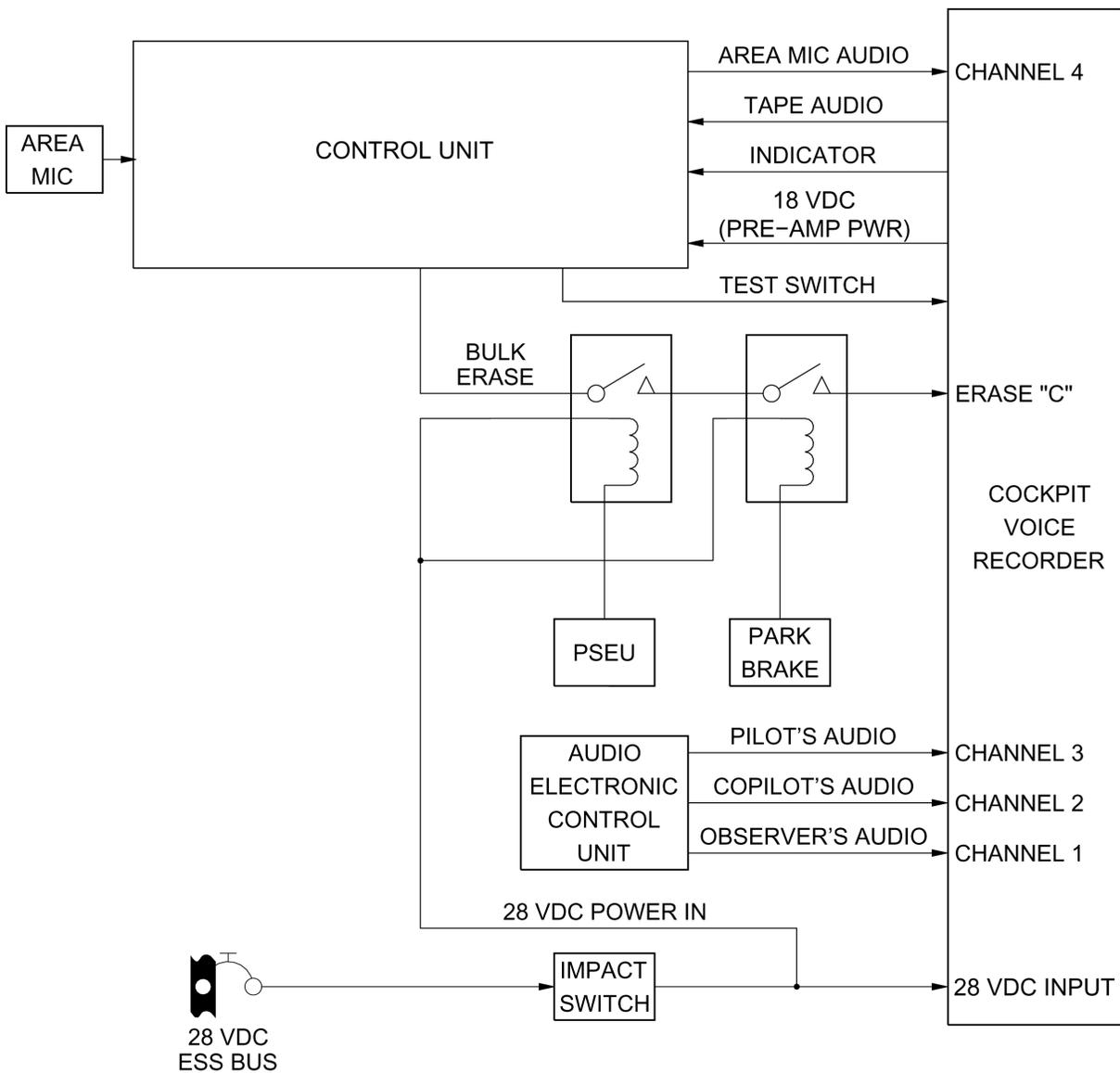


Figure 3: CRJ Aircraft Maintenance Manual, CVR System - Block Diagram

1. Microphone feedback squeal.

Toward the end of the CVR recording there are several instances where there is the sound of a squeal similar to microphone feedback. Microphone feedback, also called regeneration, occurs when the sound from a speaker re-enters the microphone. That is, when a microphone is close enough to the speaker to pick up the sound from the speaker, it is then regenerated through the microphone back into speaker, resulting in a whistle or squeal. Further evaluation of the CVR CAM channel recording shows that at least one of the two speakers was on. With the speaker volume turned on and the audio control panel switch set to I/C (intercom), either the boom microphone from the pilots' headsets or the oxygen mask microphones are active and could provide a means for regeneration. Notably, a muting circuit in the speaker channel turns the speaker off while the push-to-talk switch is pushed, preventing feedback into the speakers during a radio transmission.

From 2204:09 to 2206:23 the Captain is recorded using the oxygen mask (the sound of oxygen flow is evident) on channels 2 and 3, and, through the speaker on channel 4. The audio on channel 3, however, ceases at 2205:53 (this is discussed further in the subsequent section). Regardless, the Captain is recorded again using an oxygen mask from 2207:20 through 2208:11 on channel 2 and, through the speaker, on channel 4. Because the Captain is recorded via the speaker while using an oxygen mask, the recording indicates that the Captain had selected the I/C and MASK switches on the audio control panel, making the oxygen mask microphone active in the intercom system. The sound similar to microphone feedback is recorded on channels 2 and 4 several times only at the end of the recording after 2208:11 when the crew removes the oxygen masks. Also notable is that the broadband noise from the air driven generator increases in the channel 2 recording after 2208:11, indicating that the oxygen mask microphone remained active after the mask was removed. It appears that the oxygen mask microphone was active, recorded a higher level of cockpit noise after 2208:11 on the channel 2 recording, and thereby served as the source for regenerated noise into the speaker (causing the sound of a squeal, similar to microphone feedback).

2. Loss of audio in the CVR channel 3 recording.

In the CVR transcript it is noted that the audio on channel 3 (designated as the Pilot's audio panel information) ceases at 2205:53 (through the end of the recording). However, at 2211:34 the sound of the Morse code airport identifier for KJEF is recorded on channel 3 at a very low volume. Furthermore, the Morse code is not audible on the other channels. Notably, the FDR data shows that the microphone-left key parameter recorded an active state (keyed) that begins at the same time and continues for the remainder of the flight.

Cross-talk

The loss of audio on one channel of the CVR, in which it has been previously recording information, is not typically the result of a malfunctioning recorder. Generally, CVR malfunction or power loss results in the loss of audio on all channels. Moreover, the channel 3 recording is not completely void of audio data, indicating that the CVR was still

functioning and capable of recording. Specifically, the Morse code identifier for Jefferson City airport (KJEF) is recorded at a very low volume. The Morse code identifier is not discernable on channel 2 or 4 – however, it may be present in the recording, but due to the elevated background noise from the air driven generator (present on channels 2 and 4), it would not be audible above the noise. Further examination of the last 9 minutes of the channel 3 recording also shows that the aircraft CAS alerts and transmissions from ATC are present at a very low volume (significantly lower than previously recorded on that channel). Channel 3's audio characteristics are consistent with a recording in which there is no acoustic source, but audio from other sources has leaked into the channel's wiring (generally, referred to as cross-talk).

FDR Microphone Key

It is significant that, at the time the audio disappears from channel 3, the FDR simultaneously records an active transmit state for the microphone key parameter from the same crew station (the left pilot station). Subsequently, the air traffic control (ATC) recordings were examined for a “stuck mike” during the “keyed mike” time period (the last 9 minutes and 14 seconds before the accident). There is no evidence in the ATC recordings (R53 and R30 positions) that the accident aircraft (or any aircraft) inadvertently transmitted during this period or for the duration of the keyed state. Furthermore from the aircraft maintenance manual on the VHF communications system, if a radio is keyed to transmit for longer than 2 minutes, the affected transmitter will automatically return to the receive mode.

Emergency Mode

During normal operation the AECU acts as the switch to route the information from the microphones, radios and PC boards (which receives its information from the respective crew audio control panels) to the CVR and FDR. Specifically, within the AECU, the information is sent to a dedicated PC board from each of the crew audio control panels. However, if the audio control panel is put into emergency mode, crew communications bypass the AECU to a preset configuration (pilot communication on VHF1 and NAV1, and copilot communication on VHF2 and NAV2). Emergency mode is activated if power is lost to a single PC board within the AECU or if the audio control panel EMER/NORM switch is set to EMER. Specifically, if the respective crew station goes into emergency mode, communication for that crew station bypasses the AECU (to the preset configuration described above), but the remaining crew audio stations continue to operate normally.

At the time of the audio loss, the AECU appears to be operating normally by routing information to the CVR and FDR. At about 2205:53, it appears that the pilot's station (left audio control panel) enters emergency mode. In emergency mode, the audio bypasses the AECU and, therefore, is not sent to the CVR. Specifically, it appears that the AECU did not receive any audio from the pilot's crew station, resulting in a loss of audio on CVR channel 3. However, the recording also indicates that the other crew station audio inputs to the CVR from the AECU were not affected. According to Bombardier, with the FDR operating and the pilot station in emergency mode, the lack of information from a PC board results in the AECU sending a signal to the FDR that erroneously indicates an active state for the corresponding microphone key parameter. Given the lack of audio on channel 3 concurrent with the erroneous active state for the left microphone key parameter, it appears that the left pilot's audio control panel was in emergency mode.

3. Captain's inability to transmit at the end of the recording

At 2212:37, there are several statements made by the Captain that indicate he intended to transmit to Kansas City Center. The FDR data (microphone key parameters) and ATC audio indicate that he did not transmit anything during this time. The Captain also realizes that he is not transmitting at 2213:17, when he states, "You try yours. I'm not getting... through to her."

Given that the Captain has previously transmitted from the accident aircraft to several controllers during the flight, and communications from the aircraft are not lost subsequently, it is possible that the audio panel that the Captain was using was in emergency mode. As previously discussed, when the pilot's audio control panel is set in emergency mode, the communications for the pilot bypass the AECU and are routed directly to VHF1 (and the copilot is routed to VHF2). Additionally, according to the aircraft maintenance manual, the handheld microphone is not operable when in emergency mode. The FDR data for the time period in question does not show any microphone keys on the right side, and the left side microphone key is showing a continuous active state (as discussed in the previous section).

From the prior section, due to the loss of audio on channel 3 coupled with the erroneous active state of the Microphone Key-L parameter, it appears that the left audio control panel was in emergency mode during the time that the Captain attempted to transmit. Given that the Captain was using the left audio control panel at this time, his transmissions would not have gone through to the controller if he had attempted to use the handheld microphone or use his headset and the VHF1 radio was not tuned to the correct ATC frequency.

4. Evaluation of radio transmissions using CVR, FDR, and ATC information

In evaluating the prior three sections, the data from three independent sources, the CVR, FDR and ATC audio re-recordings, were cross checked. The ATC and CVR audio recordings were correlated to the FDR microphone key parameters using time and duration of transmission.

Flight sequence: Pre-takeoff through climb-out (2117:11 to 2143:49 CDT).

Prior to the CVR recording start, the ATC audio was transcribed and correlated to FDR microphone key information. Crew identification was ascertained using the crew identification established from the CVR group meeting. The FAA did not transcribe this portion of the flight, but provided a synopsis in their accident package (see ATC-3 Attachment 1: FAA Accident Package FLG3701). The times noted in the table were obtained directly from the ATC re-recording using an IRIG time code signal translator. The FDR microphone key parameter for the left and right audio control panels are provided.

Flight sequence: Climb-out to FL410 through accident (2144:44 to 2215:07 CDT).

The CVR recording started approximately 30 minutes prior to the accident. The events recorded by the CVR were transcribed during the CVR group (see CVR Group

Chairman’s Factual Report). The FDR microphone key parameter for the left and right audio control panels are provided.

All ATC transmissions or intended transmissions are compiled in Table 1. Although ATC-source events are generally not included, some ATC transmissions are incorporated for clarification purposes. Events relevant to the sections previously discussed are included in the table. Items in red, blue or yellow indicate significant events in the flight and are highlighted for reference.

Table Legend

CAPT = Voice identified as the Captain	R29, R30, R53 = Kansas City Air Route Traffic Control Center positions
FO = Voice identified as the First Officer	L = Push-to-talk signal routed through left audio control panel (Pilot’s side of the aircraft)
CD = Little Rock Air Traffic Control Tower (Clearance Delivery)	R = Push-to-talk signal routed through right audio control panel (Co-pilot’s side of the aircraft)
LC = Little Rock Air Traffic Control Tower (Local Control)	? = Data unknown
RW = Little Rock Air Traffic Control Tower (Radar West)	- = Data not applicable
R4, R21, R27, R35 = Memphis Air Route Traffic Control Center positions	

Table 1: Compilation of CVR, FDR and ATC radio transmissions and other events

Time (CDT)	ATC Posn	Crew ID	Mic Key	Event/Transmission Content
21:04:50	CD	FO	-	[aircraft requests and receives clearance to Minneapolis]
21:17:11	LC	FO	?	“tower Flagship thirty seven zero one is ready for taxi we’re over here in the holding area by the terminal.”
21:17:23	LC	FO	?	“two two right thirty seven zero one.”
21:20:05	-	-	-	START OF FDR DATA (per the FDR Group Chairman’s Factual Report)
21:21:00	LC	FO	R	“Flagship thirty seven zero one ready two two right.”
21:21:08	LC	FO	R	“fly heading Flagship two * thirty seven zero one cleared for take off two two right.”
21:22:21	LC	FO	R	“two six zero going to departure have a good night.”
21:22:41	RW	FO	R	“departure Flagship thirty seven zero one ah climbing two point two up to four thousand.”
21:22:54	RW	FO	R	“turn heading north and ah one five thousand Flagship * thirty seven zero one.”
21:24:08	RW	CAPT	L	“thirty seven zero direct Columbia.”
21:24:14	RW	CAPT	L	“ah just want to confirm for ah thirty seven zero one Columbia’s C-O-U?”
21:24:18	RW	CAPT	?	“thanks.” NOTE: if microphone is keyed for less than one second, the event may not be captured by the FDR.
21:26:15	RW	-	-	ATC [Flagship thirty seven zero one contact Memphis Center on one two six point eight five]
21:26:23	RW	-	-	ATC [Flagship thirty seven zero one Memphis Center one two six point eight five]
21:26:39	RW	-	-	ATC [Flagship thirty seven zero one Memphis Center on one two six point eight five]
21:26:43	RW	CAPT	R	“twenty six eighty five you have a good day.”
21:26:52	R4	CAPT	R	“and center good evening Flagship thirty seven zero one level fifteen thousand.”
21:27:00	R4	CAPT	R	“two three oh for thirty seven oh one.”
21:29:20	R4	CAPT	R	“thirty two forty two you have a good night.”
21:29:26	R21	CAPT	R	“and center good evening Flagship thirty seven zero one is ah twenty two point three for two three oh.”
21:29:36	R21	CAPT	R	“** three zero for thirty seven oh one.”
21:30:30	R21	CAPT	R	“thirty two thirty seven you have a good day.”
21:30:34	R27	CAPT	R	“center ** Flagship ah thirty seven zero one climbing through twenty three and a half for * three three oh.”
21:33:24	R27	-	-	ATC [controller relays score of baseball game (3-2 bottom of the 5 th , Houston leading game)]
21:33:33	R27	FO	L	“can’t beat my Houston.”
21:33:48	R27	-	-	ATC [controller relays score of baseball game (4-3 St. Louis now leading)]
21:34:04	R27	FO	L	“that’s October talking for ya.”
21:34:15	R27	FO	L	“apologies ***.”

Table 1: Compilation of CVR, FDR and ATC radio transmissions and other events

Time (CDT)	ATC Posn	Crew ID	Mic Key	Event/Transmission Content
21:35:22	R27	CAPT	R	"and center Flagship thirty seven oh one."
21:35:26	R27	CAPT	R	"ah we'd like to get ** higher up *** probably get up to four one oh if possible."
21:35:38	R27	CAPT	R	"roger thirty seven oh one."
21:35:58	R27	CAPT	R	"all right thirty five twenty two you have a good night."
21:36:04	R35	CAPT	R	"and center good evening Flagship thirty seven zero one ah thirty one point seven ** three oh."
21:36:13	R35	CAPT	R	"flight level four one oh thirty seven oh one thank you."
21:43:33	R35	FO	L	"thirty two sixty five thirty seven zero one good night."
21:43:39	R29	FO	L	K-C center Flagship thirty seven zero one's checking in thirty seven point two climbing to four one oh.
21:44:44	-	-	-	START OF CVR RECORDING
21:49:36	R29	FO	L	"yeah that'll be great thirty seven zero one direct KASPR."
21:49:44	R29	FO	L	"thank you sir appreciate that thirty seven zero one going direct KASPR you saved us two minutes."
21:52:02	R29	CAPT	R	"twenty five sixty seven you have a good night thirty seven oh one."
21:52:09	R30	CAPT	R	"Kansas City center good evening Flagship thirty seven zero one four one oh."
21:53:47	R30	CAPT	R	"thirty seven zero one that's affirmative."
21:53:51	R30	CAPT	R	"yeah we're actually a ah. there's ah. we don't we don't have any passengers on board so we decided to have a little fun and come on up here."
21:53:59	R30	CAPT	R	"this is our actually our service ceiling."
21:54:29	R30	CAPT	R	"and center thirty seven oh one."
21:54:32	R30	CAPT	R	"yeah just as you said it looks like we're not even going to be able to stay up here ah look for maybe ah three nine oh or three seven."
21:54:38	-	-	-	[sound similar to stick shaker] NOTE: start of aircraft upset.
21:54:39	-	-	-	[sound similar to auto pilot disconnect]
21:54:45	R30	CAPT	R	"say again for thirty seven oh one."
21:54:56	R30	-	L	[sound of warbler, similar to stick pusher warning] - NOTE: warbler sound from unknown aircraft recorded on ATC center recording for about 1 second
21:55:06	R30	CAPT	R	"declaring emergency. stand by."
21:55:21	-	-	-	FDR not recording data - NOTE: Emergency power. §
21:55:21	R30	-	?	CAS: "engine oil." - NOTE: mechanical voice stating , "engine oil" recorded on ATC center recording.
21:55:40	R30	CAPT	?	"stand by for thirty seven oh one."
21:59:17	-	-	-	FDR powered, data recording – NOTE: power restored (APU). §
21:59:46	R30	CAPT	R	"and center Flagship thirty seven oh one."
21:59:51	R30	CAPT	R	"yeah we're still descending we're gonna need to descend down ah probably lower probably gonna descend down to right now to about thirteen thousand feet is that okay?"
22:00:12	R30	CAPT	R	"all right two nine six five thirty seven zero one."
22:01:01	R30	CAPT	R	"ah thirty seven oh one stand by."
22:03:00	R30	CAPT	R	"and thirty seven oh one we can change frequency at this time."
22:03:03	R30	-	-	ATC recording recorded the controller responding to aircraft - response not recorded on CVR.
22:03:06	R30	CAPT	R	"center thirty seven oh one you there."
22:03:15	R30	CAPT	R	"ah we had an engine failure up there at altitude it at ah airplane ah went into a stall and one of our engine's failure..."
22:03:30	R30	CAPT	R	"ah right now we're not we're- stand by for that. we're descending down to thirteen thousand to start this other engine. we'll tell you."
22:03:50	R30	CAPT	R	"thirty four five good day."
22:03:52	R53	CAPT	R	"center Flagship thirty seven zero one's with you ah coming through eighteen thousand for thirteen."
22:04:02	R53	CAPT	R	"will do thirty seven oh one."
22:05:53	-	-	L	Through end of recording: Audio ceases on channel 3 (except for low-volume cross-talk), FDR microphone key L shows keyed.
22:06:26	R53	CAPT	R	"and cent- center thirty seven oh one we're gonna need a little lower ah to start this other engine up so we're gonna go down to about twelve or eleven is that cool?"
22:06:38	R53	CAPT	R	"ah we'll go down to at least eleven thousand thirty seven oh one."
22:06:48	R53	CAPT	R	"ah just stand by right now we're gonna start this other engine and see make sure if everything's okay."

§ If the aircraft is using emergency power (such as from the air driven generator), the FDR is not powered and cannot record data, but the AECU and CVR remain powered and operating.

Table 1: Compilation of CVR, FDR and ATC radio transmissions and other events

Time (CDT)	ATC Posn	Crew ID	Mic Key	Event/Transmission Content
22:06:59	R53	CAPT	R	"roger * thirty seven oh one thank you."
22:08:11	-	-	-	[sound similar to oxygen mask removal]
22:08:15	-	-	-	[sound similar to oxygen mask removal]
22:08:17	-	CAPT	-	"um. switch."
22:08:26	-	-	-	[sound of clunks]
22:09:06	R53	FO	R	"thirty seven zero one we need direct to any airport. we have a double engine failure."
22:09:15	R53	FO	R	"closest air- air- airport. we're descending fifteen hundred feet per minute we have ah nine thousand five hundred feet left."
22:09:23	R53	FO	R	"what is the three letter identifier?"
22:09:28	R53	FO	R	"K-J-E-F."
22:10:36	R53	FO	R	"I-L-S three zero. what is the frequency please."
22:10:54	R53	FO	R	"the approach frequency is one two four one or what is the I-L-S frequency?"
22:11:03	R53	FO	R	"what is the I-L-S frequency again?"
22:11:22	R53	FO	R	"thank you much."
22:11:27	R53	FO	R	"one one zero five."
22:11:34	-	-	-	[Morse Code identifier for KJEF recorded only on channel 3 (low volume)]
22:11:51	R53	FO	R	"roger that thanks."
22:11:59	-	-	-	[sound of squeal, similar to microphone feedback]
22:12:08	-	-	-	[sound of squeal, similar to microphone feedback]
22:12:24	R53	FO	R	"thirty seven zero one. how do we look for the airport?"
22:12:37	-	CAPT	-	"how do we look for the runway?" - NOTE: this event was not recorded on the ATC center recording.
22:12:44	-	-	-	[sound of squeal, similar to microphone feedback]
22:12:45	-	CAPT	-	"three sixty heading. * turn in now?" - NOTE: this event was not recorded on the ATC center recording.
22:12:59	-	CAPT	-	"turn left three sixty heading. are we gonna make this airport? **." - NOTE: this event was not recorded on the ATC center recording.
22:13:07	-	-	-	[sound of squeal, similar to microphone feedback]
22:13:09	-	CAPT	-	"we don't have the airport in sight. we're heading three six zero now. do you have anything further information." - NOTE: this event was not recorded on the ATC center recording.
22:13:20	R53	FO	R	"how do we look now three six heading we do not have airport in sight."
22:13:28	R53	FO	R	"turning three fifty."
22:13:32	R53	FO	R	"I have the beacon in sight..."
22:13:36	R53	FO	R	"** head."
22:13:38	R53	FO	R	"I do not see the runway. I have the beacon..."
22:13:49	R53	FO	R	"Flagship thirty seven zero one have the beacon twelve o'clock the runway is at heading zero three zero?"
22:13:59	R53	FO	R	"okay I think I have the approach end in."
22:14:39	-	FO	R	"we're not gonna make the runway. is there a road?" - NOTE: this event was not recorded on the ATC center recording.
22:15:07	-	-	-	END OF CVR RECORDING

5. Irregularity between radio transmission identity and source

As previously discussed, the FDR receives its information for the microphone key parameters from the AECU via the individual audio control panels. The signals for the push-to-talk switches are routed through the respective audio control panel PC boards within the AECU. The AECU then determines which VHF radio to send the audio to for transmission (as configured in the audio control panel). The AECU also sends the information about which push-to-talk switch is activated to the FDR for the corresponding FDR microphone key parameter.

In reviewing the crew identification for each of the radio transmissions in Table 1, it is evident that at the beginning of the flight the First Officer’s transmissions are transmitted via the right audio control panel and the Captain’s transmissions are transmitted via the left audio control panel. At 2126:15 ATC transmits a frequency change to the aircraft three times. The crew’s response is not recorded until 2126:43, at which time the Captain is identified as speaking, and the transmission is sent via the right audio panel (this section is highlighted in blue in Table 1). Transmissions from the first officer after 2126:43 are transmitted via the left audio control panel. Also, according to the FDR data, the autopilot is engaged during this time—it is engaged for approximately 80 seconds starting at 2125:56 (it had not been engaged prior to this during the climb-out).

The configuration of the Captain transmitting via the right audio control panel and the First Officer transmitting via the left audio continues through the aircraft upset sequence and the majority of the descent (until 2209:06). Notably at 2206:59 the captain is identified as transmitting via the right audio panel; this is the last successful radio transmission attributed to the Captain. At 2209:06 the First Officer is identified as transmitting via the right audio control panel (this section is also highlighted in blue in Table 1). The audio panel/crew configuration results are summarized as shown in Table 2:

Time Period	Left Audio Panel	Right Audio Panel
2121:00 – 2124:14	Captain	First Officer
2126:43 – 2206:59	First Officer	Captain
2209:06 – 2214:39	No Information	First Officer

Table 2: Matrix of audio control panel push-to-talk source (left or right) for radio transmissions attributed to the Captain and First Officer for the specified time periods.

6. Synopsis of engine checklist usage, based on CVR events

Select events are compiled for reference in the investigation regarding engine re-start and oxygen mask usage (see Table 3). Select events are highlighted for reference. Please refer to the Double Engine Failure checklist (see attached).

Table 3: Engine restart and oxygen mask usage events.

Time	Content/Event
2154:32	Crew transmits to ATC that they would like lower altitude (FL370 or FL390).
2154:38	[sound similar to stick shaker]
2154:39	[sound similar to auto pilot disconnect]
2154:55	[sound of triple chime, similar to master warning alert] - CAS warning of engine oil.
2155:06	Crew transmits to ATC that they are having an emergency.
2155:09	[sound of triple chime, similar to master warning alert] - CAS warning of engine oil.
2155:21	FDR not powered (no FDR data recorded).
2155:23	comment regarding loss of engines.
2155:28	[sound of increased background noise, similar to air driven generator operation]
2156:42	Start of double engine failure checklist (pg. EP 1-5).
2157:04	CAS warning of cabin pressure.
2158:21	comment to use oxygen masks.
2158:41	[sound similar to oxygen flow starting in oxygen mask]
2159:17	APU on (FDR powered, data recorded).
2201:36	Double engine failure checklist - Relight using windmill (pg. EP 1-6).
2201:51	comment regarding lack of N2 indication and need to try the APU relight.
2202:14	Double engine failure checklist - Relight using APU bleed air (pg. EP 1-8, items 1-4).
2202:31	[sound of chime, similar to master caution alert] - crew stops checklist.
2204:06	comment to use oxygen masks.
2204:09	[sound similar to oxygen flow starting in oxygen mask]
2204:13	comment regarding cabin altitude of fifteen thousand four hundred.
2204:26	Captain briefs double engine failure checklist - Relight using APU bleed air (pg. EP 1-8).
2206:23	[sound similar to oxygen mask removal]
2207:02	Captain references thirteen thousand feet altitude.
2207:04	Double engine failure checklist - Relight using APU bleed air, engine 1 (pg. EP 1-8, items 1-5).
2207:17	comment regarding start time.
2207:20	[sound similar to oxygen flow in oxygen mask]
2207:38	comment to stop.
2207:41	Double engine failure checklist - Relight using APU bleed air, engine 2 (pg. EP 1-8, items 1-5).
2208:04	comment regarding lack of N2.
2208:11	[sound similar to oxygen mask removal]
2208:15	[sound similar to oxygen mask removal]
2209:06	Crew transmits to ATC that they have a double engine failure and need to get to an airport.
2209:32	Double engine failure checklist - Relight using APU bleed air.
2211:42	Double engine failure checklist - Relight using APU bleed air.
2212:07	comment regarding lack of N2 indication.
2215:07	End of CVR recording.

Anna Cushman
Aerospace Engineer (CVR/FDR/Sound)

Attachment: Northwest AirlinK Candadair Regional Jet Quick Reference Handbook – Double Engine Failure checklist



Double Engine Failure

1. CONT IGNITION ON

If engines continue to run down:

2. Thrust Levers (both) SHUT OFF

3. ADG Manual Deploy Handle PULL

When ADG power is established:

4. STAB TRIM CH 2 ENGAGE

5. Target Airspeed ESTABLISH

AIRPLANE FLIGHT LEVEL	TARGET AIRSPEED
ABOVE FL 340	0.7 MACH
BELOW FL 340	240 KIAS

Maintain airspeed until ready to restart engines.

6. APU (below 30,000 feet) START
7. APU GEN (if APU available) ON

Check/reset barometric altimeter setting, altitude preselector, V-speeds and speed bug settings after ADG deployment or APU generator switching.

Windmilling relight possible (requires airspeed of not less than 300 KIAS):

? YES

(From 21,000 feet or below)

8. Relight Using Windmilling Procedure
 (See Page EP 1-6) ACCOMPLISH

Maintain 240 KIAS until ready to initiate windmill start.

NO

(From 13,000 feet and below)

8. Relight Using APU Bleed Air Procedure
 (See Page EP 1-8) ACCOMPLISH

**Maintain between 190 KIAS (23,000 kg–51,000 pounds)
 and 170 KIAS (16,000 kg – 36,000 pounds).**

— CONTINUED —



Double Engine Failure (Cont)

Relight using windmilling:

**From 21,000 feet and below:
Attempt to start both engines at the same time.**

1. CONT IGNITION CHECK ON
2. Airspeed..... NOT LESS THAN 300 KIAS

An altitude loss of approximately 5,000 feet can be expected when accelerating from 240 to 300 KIAS.

NOTE

Airplanes 7002 through 7304—With the ADG deployed, during a windmilling start, an airspeed of 330 knots is permitted for 12 minutes, or an airspeed of 335 knots is permitted for 4 minutes.

Airplanes 7305 and subsequent—There are no air-speed limitations with the ADG deployed during flight.

When ITT is 90°C or less and N₂ is:

- At least 12% (above 15,000 feet) or
- At least 9% (15,000 feet and below):

3. Thrust Levers (both) IDLE
4. Airspeed..... NOT LESS THAN 300 KIAS
Maintain airspeed until start is complete (stable idle).
5. Engine Indications MONITOR

At least one engine relights within 25 seconds:

? **YES**

1. Thrust Lever(s) AS REQUIRED

Airplanes 7002 through 7304:

2. Airspeed..... NOT MORE THAN 250 KIAS

Airplanes 7305 and subsequent:

2. No airspeed limitation with the ADG deployed
3. Affected GEN CHECK ON
 - Check flight instruments. Reset if necessary.
4. L AND/OR R 10th STAGE BLEED(s) CHECK OPEN
5. Applicable PACK(s) CHECK ON
6. ADG Manual Deploy Handle STOW
7. ADG PWR TXFR..... OVERRIDE
8. Single Engine Procedures
(See Page AP 1-2)..... ACCOMPLISH IF REQUIRED

—END—

NO

6. Thrust Levers SHUTOFF

— CONTINUED —



Double Engine Failure (Cont)

Relight using windmilling:

Another windmilling relight attempt still possible:

? **YES**

7. Airspeed 300 TO 335 KIAS

8. Wait 30 seconds, then repeat relight procedure.

NO

7. Relight using APU bleed air.

— CONTINUED —



Double Engine Failure (Cont)

Relight using APU bleed air:

From 13,000 feet and below:

1. Target airspeed..... REESTABLISH
- | | |
|------------------------|--------------------------------|
| AIRPLANE WEIGHT | TARGET BEST GLIDE SPEED |
| 23,000 kg (51,000 lb) | 190 KIAS |
| 16,000 kg (36,000 lb) | 170 KIAS |
2. L and R 10TH STAGE BLEED..... CLOSED
 3. APU LCV OPEN
 4. CONT IGNITION CHECK ON

Attempt to start one engine at a time:

5. L or R ENG START PUSH

When N₂ is 28% or greater and ITT is 90°C or less:

6. Thrust Lever IDLE
7. Engine Indications MONITOR

Engine relights (within 25 seconds):

? **YES**

1. Thrust Lever AS REQUIRED

Airplanes 7002 through 7304:

2. Airspeed..... NOT MORE THAN 250 KIAS

Airplanes 7305 and subsequent:

No airspeed limitation with the ADG deployed.

3. Operative GEN CHECK ON
 - Check flight instruments. Reset if necessary.
4. Applicable 10TH STAGE BLEED..... CHECK OPEN
5. Applicable PACK CHECK ON
6. ADG Manual Deploy Handle STOW
7. ADG PWR TXFR..... OVERRIDE
8. Single Engine Procedures
(See Page AP 1-2)..... ACCOMPLISH

— END —

NO

8. Affected Engine, Thrust Lever SHUTOFF
9. Affected ENG STOP PUSH
10. Attempt relight on other engine. _____

Neither engine is restarted:

— CONTINUED —



Double Engine Failure (Cont)

Neither engine is restarted:

1. Consider a forced landing or ditching. Notify cabin crew.
2. Thrust Levers (both)..... SHUTOFF
3. Target airspeed REESTABLISH

AIRPLANE WEIGHT TARGET BEST GLIDE SPEED

23,000 kg (51,000 lb) 190 KIAS

16,000 kg (36,000 lb) 170 KIAS

4. Prepare for a forced landing or ditching (See Page EP 7-2).

— — — END — — —